Drury & Rutt

Central Station Heating
at Urbana, Illinois

Mech. Engineering
B. S.

1903

CENTRAL STATION HEATING AT URBANA, ILLINOIS

BY

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THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE

IN MECHANICAL ENGINEERING

IN THE
COLLEGE OF ENGINEERING
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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

RALPH SOUTHWARD DRURY and ROY WEAVER RUTT

ENTITLED CENTRAL STATION HEATING AT URBANA, ILLINOIS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering.

L. P. Breckenridge

HEAD OF DEPARTMENT OF Mechanical Engineering.

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URBANA, ILLINOIS.
BUSINESS CENTER.
MAIN
PLANT.

INTRODUCTION

The subject matter herein contained is a descriptive review and test, taken during the winter of 1902-1903, of the central heating system of the Urbana Light, Heat and Power Company, located at Urbana, Illinois.

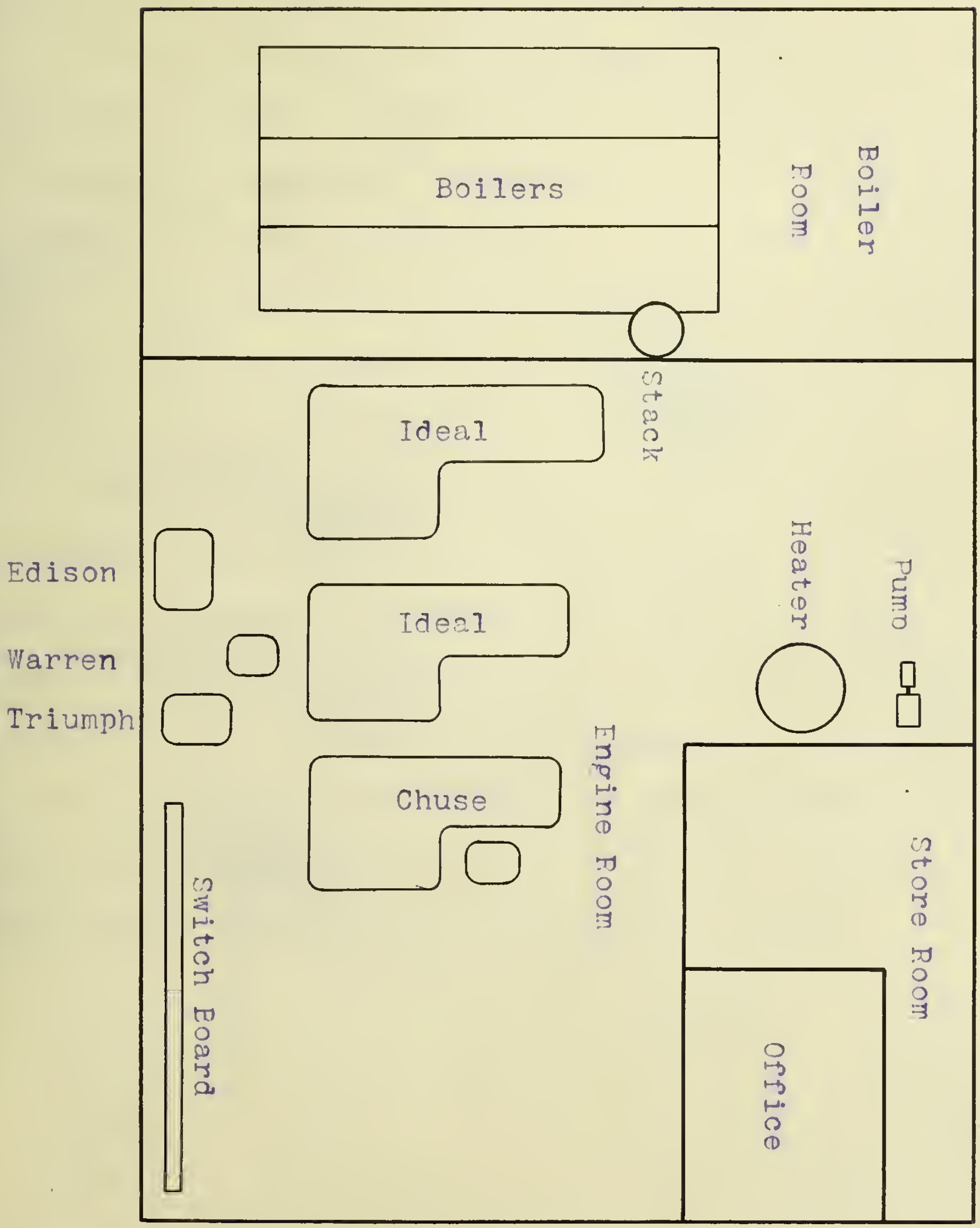
DESCRIPTION OF SYSTEM.

Located at the corner of Water and Walnut Streets, in a forty by ninety-five foot one story brick building, is contained the entire mechanical equipment of the central station which supplies light, heat and electrical power to the City of Urbana. In the rear of this building are three similar horizontal multi-tubular hand fired boilers, made by the Murray Iron Works of Burlington, Iowa. The principal features of each boiler are exhibited in the following table:-

1	Rated horse power		150
2	Length of boiler	in feet	18
3	Diameter of shell	" "	6
4	" " flues	" inches	4
5	Number of flues		72
6	Grate area	in square feet	33
7	Boiler heating surface	" " "	1583
8	Ratio of grate area to heating surface		1:48
9	Square feet of heating surface per rated horse power		10.6

The draft for these boilers is furnished by a 110-foot steel stack, four feet in diameter.

Steam is conveyed from the boiler room through an eight inch main into the engine room to a steam separator, and then is distributed to the different engines. The following sketch shows the general arrangement of the plant.

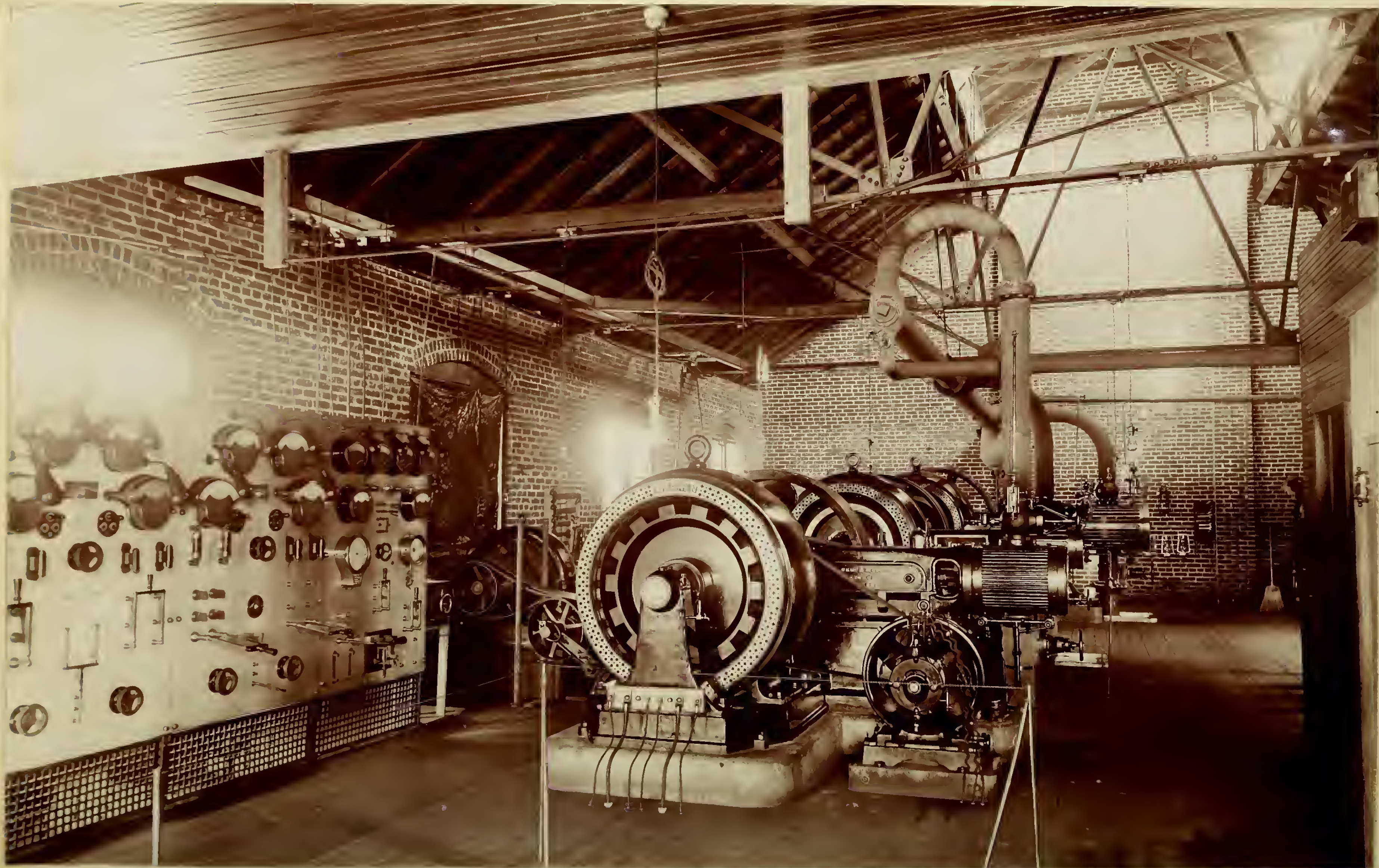


The 200 H. P. 16 X 16 inch "Ideal Special" engine shown in the sketch, made by the A. E. Ide & Sons Engine Co. of Springfield, Illinois, is direct connected to a 120 K. W. 220-2200 volt alternating current generator, manufactured by the Warren Electric Manufacturing Co., of Sandusky, Ohio. This unit is rated to run at 257 revolutions per minute. A 9-1/4 K. W. Warren exciter running at 1500 revolutions per minute is belted to this engine.

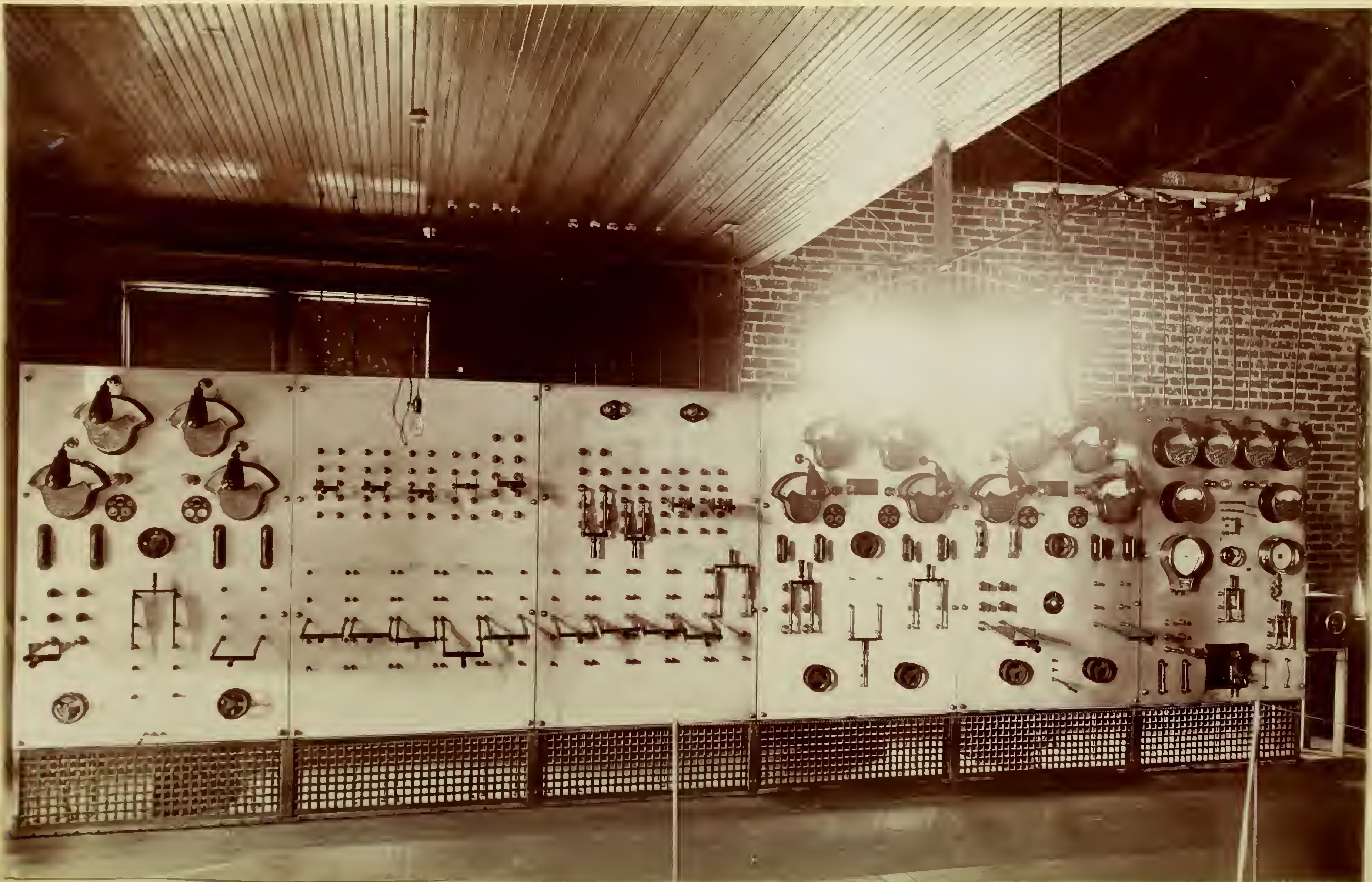
South of this is another engine of the same make, with a 13 X 13 inch cylinder, running at 200 revolutions per minute, developing 100 H. P. and direct connected to a 60 K. W. 220-2200 volt alternating current Warren generator. This engine also furnishes power to a 45 K. W. 500 volt direct current Edison generator, running at 1000 revolutions per minute, as well as to a 9-1/4 K. W. Warren exciter similar to the one connected to the larger unit.

The power equipment of the plant is completed by a 90 horse power engine which has a 12 X 13 inch cylinder and runs at 257 revolutions per minute. This engine was made by the Chuse Engine Co. of Mattoon, Illinois. It is also direct connected to a 60 K. W. 220-2200 volt Warren alternating current generator and belted to a 35 K. W. 500 volt direct current generator, manufactured by the Triumph Electric Co., of Cincinnati, Ohio. An 8-1/2 K. W. 110 volt direct current Warren exciter is also run by this engine.

INTERIOR OF ENGINE ROOM LOOKING NORTH.



SWITCH BOARD LOOKING WEST.



AUXILIARY MACHINERY.

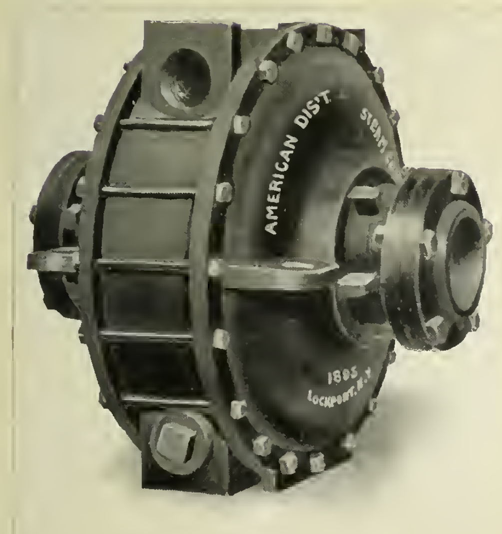
When the exhaust from the engines is only partially used or when the heating system is not in operation, it is conveyed through an eight inch pipe into a Stillwell-Bierce and Smith-Vaile Co's. feed water heater, and from here into a vertical pipe through the roof. The heater is so arranged that water may be taken either from the city main or the return main from the heating system. From here the water is fed to the boilers by a 3-2/3" X 5-1/4" X 6" Stillwell-Bierce and Smith-Vaile steam pump number 3388. The plant is also equipped for emergencies with two Pemberthy injectors; one with 1-1/4 inch and the other with 1-1/2 inch connections.

DESCRIPTION OF THE MAINS.

The main consists essentially of 427 feet of eight inch, 178 feet of seven inch, 420 feet of six inch, 350 feet of four inch and 150 feet of three inch wrought iron pipe. This is covered with asbestos and enclosed in a cylindrical tin-lined sectional wood casing tightly bound with spirally wound wire. This casing has a shell of four inches with a dead air space of one inch between the tin and asbestos. It is thoroughly covered with asphaltum, pitch and sawdust. The main was manufactured and installed by the American District Steam Co. of Lockport, New York. The accompanying figure shows the casing ready for the steam pipe.

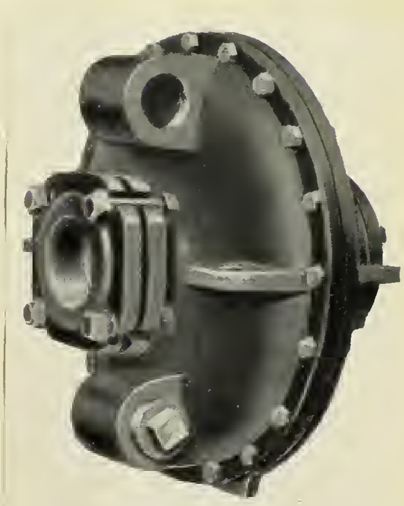
The main is buried in the earth at a depth varying from three to seven feet.

To provide for the linear expansion and contraction of the main due to the change of the temperature which it undergoes, there are placed at intervals of about one hundred feet, an automatic device called a variator. Expansion and contraction is provided for in these by copper diaphragms. The variators used are of two styles, the double and the single; the former being installed only in sections of the main between two fixed points one hundred feet or less apart and the latter is used where slight angles or deviations from a straight line are desired and for lengths of not over fifty feet. The accompanying cuts show the two different types.

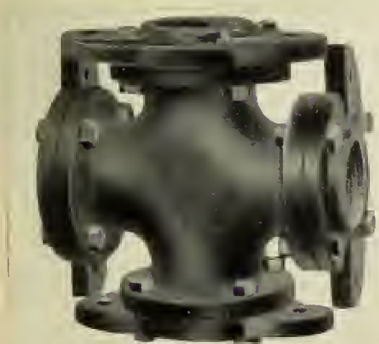


DOUBLE VARIATOR

At street corner intersections specially constructed flanged crosses are installed which have openings for continuance of the mains at right angles. Cut-off valves are bolted to the crosses; the anchorage cross and its corresponding valve being shown in the cut at the left and

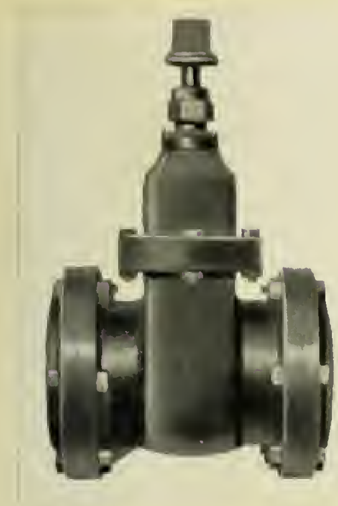


SINGLE VARIATOR



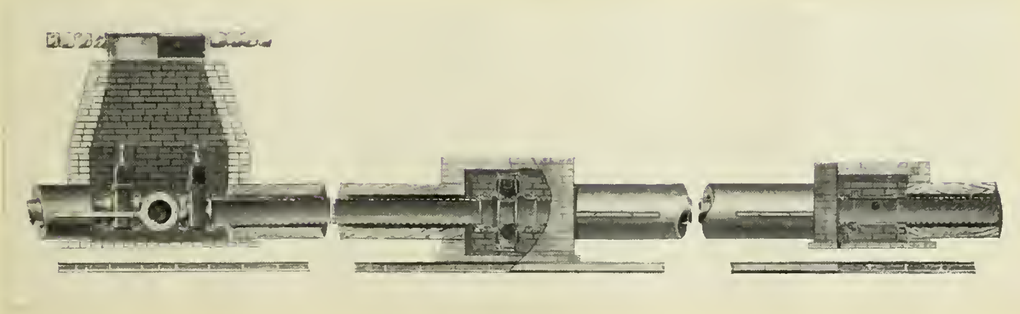
ANCHORAGE CROSS

the one below. A sectional view is shown below of a portion of the main as laid in the ground with an anchorage cross with valves in position at the left, a double variator at the center and a customer's branch at the right. The amount of masonry required in the installation of such a main is clearly shown in the view. Service mains taken from the top of the street mains are carefully graded upward from the connection to the building to be heated.



Valve

Under drainage for the line is provided by means of a drain tile, so that the casing will not at times be surrounded by water from springs, leaky water or sewer pipes. A four inch cast iron pipe which returns the water of condensation from a part of the system is laid under the street main itself.



Sectional view of the main.

BUILDINGS HEATED.

The types of buildings that are furnished with heat from the plant may be classified as public buildings, stores and offices. All of these are built of either brick or stone.

The principal features of the buildings as regards cubical contents, external wall surface, glass area and radiation installed, is exhibited in the following table, columns one to six inclusive. Columns seven to ten inclusive are added for the purpose of showing the relation of the actual radiation surface to that which would be required if calculated by Mill's rule. A fuller explanation and the uses of this rule may be found in Mill's "Warming and Ventilation of Buildings", volume II page 478. Column eleven was calculated by dividing column one by column six, and it shows the number of cubic feet of space heated by one square foot of actual radiation surface in the different buildings.

RETURN SYSTEM

BUILDINGS	Floor	Cu.ft. of Air Space	Sq.ft of Outer Wall	Sq.ft of Glass	SQ.FT. OF RADIATION: From Radiators	From Exposd Pipe	Total	SAME BY MILL'S RULE: Space Cu.ft : 200	Wall Sq.ft : 20	Glass Sq.ft : 2	Total	Ratio of Heating Surface to Cu. Space
		1	2	3	4	5	6	7	8	9	10	11
Court House	1	136190	4414	1056	1789	148	1927	681	220	528	1429	71
" "	2	146900	5104	975	1387	132	1519	734	255	487	1476	97
" "	3	167892	5750	1088	1730	54	1784	839	287	544	1670	94
Residence at Jail		17897	2073	209	302	34	336	90	104	103	297	53
County Jail		36945	2686	161	80	.408	488	184	131	80	395	75
Wahl's Saloon	1	17732	314	368	180		180	89	16	184	289	99
" "	2	4050	185	85	60		60	20	9	42	71	67
First National Bank	1	14030	735	223	277	25	302	70	37	111	218	47
Herald Office	2	17742	1082	322	414		414	89	54	161	304	43
City Hall	1	41585	3326	471	620	46	666	208	166	235	609	63
" "	2	30638	2218	391	532		532	153	111	195	459	58
Cham.Co.Abst.Office	1	22350	288	292	270	13	283	111	14	146	271	79
Owen's Grocery	1	19950	219	293	212	14	226	100	11	146	257	88
Doney & Saffer	2	11897	446	206	180		180	59	22	103	184	66
Mansf'ld Cloth. Co.	1	19950	234	284	259	31	290	100	12	142	254	69
Julian Shoe Store	1	24200	230	390	164	21	185	121	11	195	327	130
Bogg's Flat	2	41105	1053	424	633	7	640	205	52	212	469	64
Porter(Dry Goods)		64050	929	823	625	226	851	320	46	411	777	75
Blackshaw & White	2	13165	789	224	225		225	61	39	112	212	58
Hubbard H'dware Co.	1	31530	2055	348	380	21	401	157	102	174	433	79
Dr. Lindley Office	2	6760	681	89	147	1	148	34	34	44	112	46
Home Telephone "	2	6310	547	58	65		65	32	27	29	88	97
Total		888818	35103	8695	10536	1181	11712					

NON-RETURNING SYSTEM.

BUILDINGS	Floor	Cu.ft. of Air Space	Sq.ft of Outer Wall	Sq.ft of Glass	SQ.FT. OF RADIATION: From Radiators	From Exp'sd Pipe	Total	SAME BY MILL'S RULE: Space Cu.ft 200	Wall Sq.ft 20	Glass Sq.ft 2	Total	Ratio of Heating Surface to Cu. Space
		1	2	3	4	5	6	7	8	9	10	11
Busey's Bank	1	14730	291	197	255	15.6	270.6	73	14	98	185	55
Dr. Wilson's Office	2	7380	411	86	110		110.0	37	20	47	100	67
Oldham's Abs. "	1	13641	216	210	168		168.0	68	10	105	183	81
Cohen's Cigar Store	1	9035	155	183	136		136.0	45	7	92	144	66
Post Office	1	24063	1175	411	396	45.3	441.3	120	56	205	381	57
Cohen's Cigar Fact.	2	15918	1911	187	296		296.0	79	95	93	267	51
Colvin's Meat Mark.	1	11803	206	164	30	5.6	35.6	59	10	81	150	340
Dr. Morrison's Off.	2	6187	225	67	123		123.0	31	11	33	75	50
Gere's Jewelry Shop	1	15825	197	353	152		152.0	79	9	176	264	104
Lowenstern's Store	1	42045	597	244	307	10.9	317.9	210	29	122	361	172
Columbian Hotel	1	27906	961	221	541	24.5	565.5	139	48	111	298	49
" "	2	66531	2669	488	524	20.1	544.1	333	134	244	711	122
" "	3	26094	1140	320	183		183.0	130	57	160	347	142
Burre's Flat	1	21534	1161	374	419	22.5	441.5	108	58	187	353	49
" "	2	17080	1072	155	232	1.2	233.2	85	53	77	215	73
Clark's Marble Wks.	1	20585	1150	282	201		201.0	103	58	141	302	102
Fire Department	1&2	46277	4756	328	270	180.5	450.5	231	217	164	612	102
Total		386634	17892	4270	4344	326.2	4669.2					

SQUARE FEET OF RADIATION IN BASEMENTS.

RETURNING SYSTEM	PLACE	SQ. FT. OF PIPE
	Court House	215
	Wahl's Saloon	209
	City Hall	80
	Champaign Co. Abstract Office	67
	Owen's & Mansfield	38
	Julian Shoe Store	29
	Hubbard Hdware Store	24
	Total------------	662

NON-RETURNING SYSTEM

	Busey's Bank	10
	Oldham's Abstract Office	5
	Cohen's Cigar Store	30
	Post Office	17
	Colvin's Meat Market	23
	Gere's Jewelry Store	44
	Columbian Hotel	73
	Burres' Flat	43
	Clark's Marble Works	45
	Fire Department	106
	Total------------	396

NOTE:-

Radiation from covered pipe is taken at one-fifth the value of radiation from bare pipe. This conclusion was drawn from the table on the following page taken from Kent's Pocket Book page 471.

STEAM PIPE COVERINGS.

Kind	Lb. steam condensed per sq.ft per hour.	B. T. U. per sq. foot per minute.	B. T. U. per sq. ft. per hr. per deg. of avg. dif. of temp.	Saving due to covering. Lb. per hr per sq.ft.	Ratio of heat lost. Bare to covered pipe.
Bare Pipe	.846	12.27	2.706		1.0
Magnesia	.120	1.74	.384	.726	14.2
Rock Wool	.080	1.16	.256	.766	9.5
Mineral Wool	.089	1.29	.285	.757	10.5
Fire Felt	.157	2.28	.502	.689	18.6
Manville Sect'l	.109	1.59	.350	.737	12.9
" Wool Cement	.108	1.56	.345	.738	12.7
Mineral Wool	.099	1.44	.317	.747	11.7
Hair Felt	.132	1.91	.422	.714	15.6
Riley Cement	.298	4.32	.953	.548	35.2
Fossil Meal	.275	3.99	.879	.571	32.5

JOHNSON REGULATING SYSTEM.

The Johnson system of temperature regulation is installed in the Champaign County Court House which is one of the buildings on the return system. Its operation is very simple and will be described briefly in the following lines.

Compressed air is the motive power which operates the valves or dampers used for this temperature regulation, since it is the most useful of power mediums for the circumstances under which the system must work. The air pressure is obtained by means of utilizing the water pressure in the building as power for the compressor, which is shown by the accompanying figure. Suffice it to say that one of the pipes at the bottom of figure 1 is connected to the water supply of the building and the other pipe to the waste; the pipe shown at the top being connected to the air pipes of the building. The compressor automatically compresses the air to about ten pounds per square inch and then moves only as the air is used, the amount of water consumed being extremely small.

Figure 1

The temperature regulation is affected by means of a thermostat, placed on the wall of the room heated, which controls the source of heat. This thermostat, shown in a side view in figure 2, is connected to the compressor; before mentioned, and to a diaphragm valve, figure 3, which in turn is connected to the radiator at the entrance of the steam pipe by small air pipes in the wall of the building.

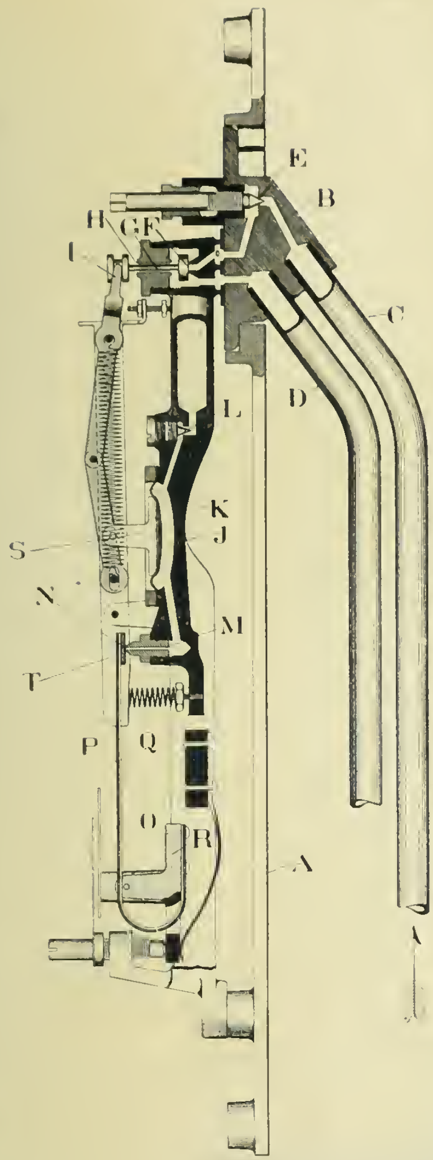


Figure 2

The metallic strip O shown in figure 2 is made up of two pieces of very thin strips of steel and brass, and since brass expands and contracts more readily than steel from the heat and cold, the strip O will be varied to the right or left when the temperature rises or falls. By this variation the different levers either open or close the valve N, which in turn increases or decreases the air pressure, and thus actuates the diaphragm F shown in figure 3. Taking the case of the temperature rising, i.e. of O figure 2 moving to the left, the air pressure on the diaphragm F will increase and the valve B figure 3 will be lowered; thus shutting off the steam supply and allowing the room temperature to fall. Then when the temperature falls the opposite action takes place in the thermostat; thereby keeping a nearly constant room temperature by this continuous operation. The thermostat is generally set to operate at 70 degrees Fahrenheit.

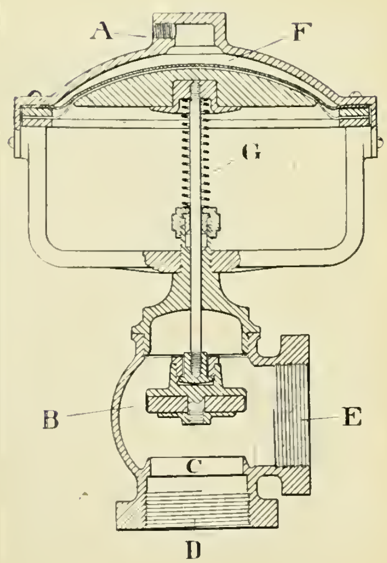


Figure 3

COOLING OR ECONOMIZING COILS.

The heat from the water of condensation is utilized from the greater part of the system by returning it to the plant through cast iron mains to be used as feed water for the boilers. In the places where this method is not employed, economizing coils are used. Cast iron not being affected by the chemical properties of hot water, a continuous circulating economizing or cooling coil is placed in each building heated, and all water of condensation is discharged into it from the steam trap. The coil is generally placed in a tin-lined box having an inlet for fresh air and an outlet for hot air leading to a register placed in the floor above. The water leaves the coil a few degrees warmer than the temperature of the surrounding air and is then thrown into the sewer. The cut shown below is a semi-sectional view of the coil.

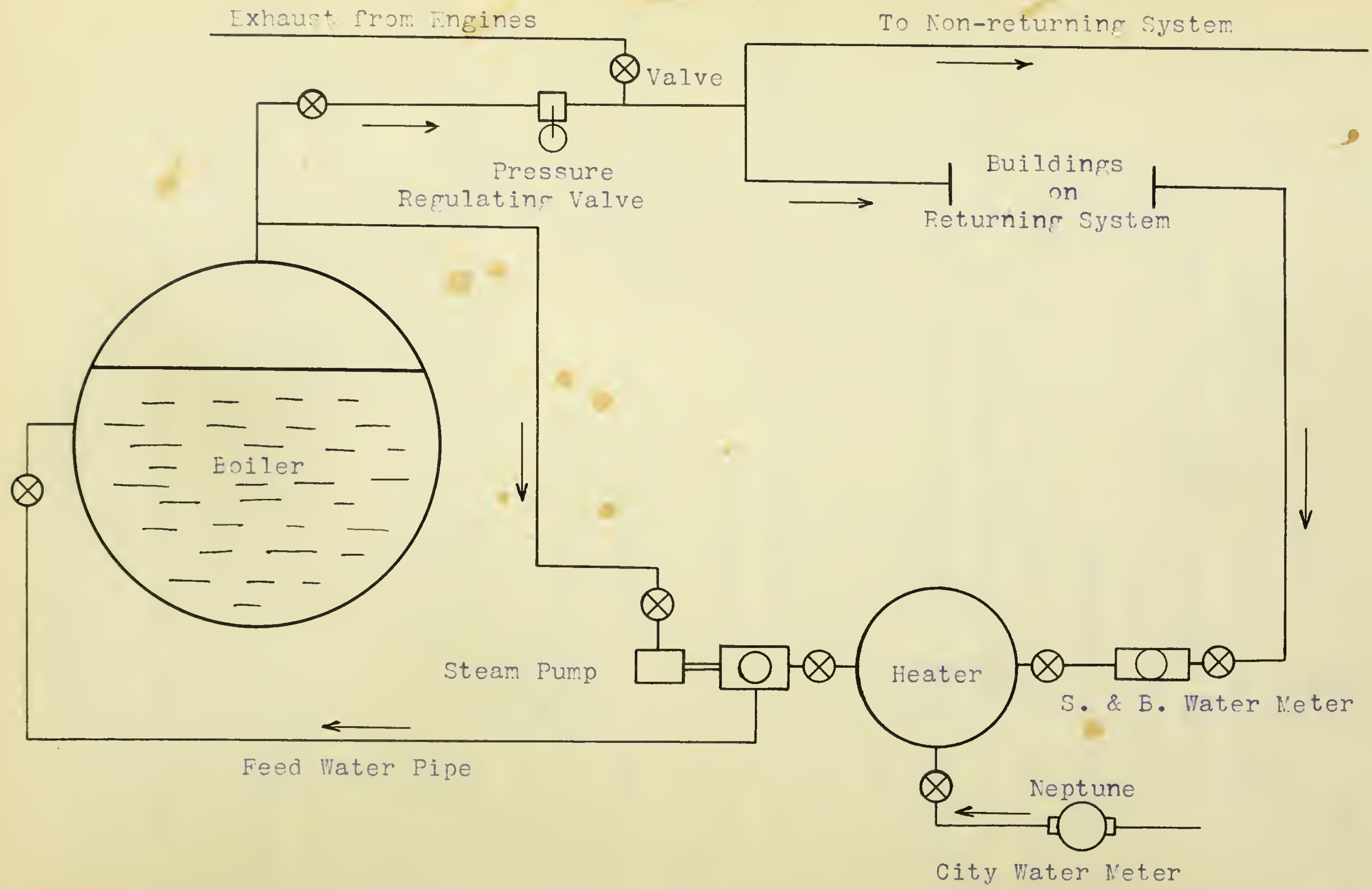
Tests on the whole system.

OBJECT

The tests on the whole system were taken to determine the amount of water condensed per square foot of radiation under various temperature conditions and to find the boiler horse power required for the system under these conditions.

DESCRIPTION OF APPARATUS

The diagram on the following page shows the water circuit of the heating system. Both the city water and the return water of condensation were used in feeding the boilers. The Schaeffer and Budenburg meter registered the amount of water condensed in the returning system. Since the returned water was insufficient to keep the water-level in the boiler constant, it was necessary to pump more water from the city main. Hence the Neptune meter registered the amount of water condensed and thrown away in the non-returning system. Thermometers were used in determining the temperature of the water of condensation, of external air, and internal temperature of the buildings on the system. The pressure in the main was determined by means of a steam gauge.



DIAGRAMATIC SKETCH OF APPARATUS.

METHODS OF PROCEDURE.

Before starting a test, we saw that the water in the two boilers was at the same height under normal conditions. Then this water level was marked by a string around the water glass. With these preliminaries, the test was begun; simultaneous readings being taken of the following gauges and instruments at given intervals:-

Time.

Schaeffer & Budenburg water meter #533 on the return main.

Neptune water meter #68374 on city water connection.

Boiler pressure.

Heating main pressure at plant.

Temperature of condensation water in return mains before entering meter.

Temperature of external air.

In addition to these, the temperatures of the rooms of the different buildings wre observed at various intervals during the day; a mean of which is recorded in the results. The readings at the start and finish are the only ones of practical value; the intermediate ones being taken so as to make sure that everything was in working order throughout the test and to enable us to stop the test at any time in case of an accident or breakdown.

The amount of radiating surface in use during the test was determined by frequent visits to the buildings heated by the plant. The following sample sheet shows the method employed in the determination of the square feet of radiation in use in each room. That is, we observed what radiators were in use and compared with the data on this sheet.

TABLE OF CUBICAL CONTENTS, EXTERNAL WALL SURFACE, GLASS AREA AND RADIATING SURFACE.

Place Herald Office Measured by Rutt & Drury Date Feb. 6, 1903.

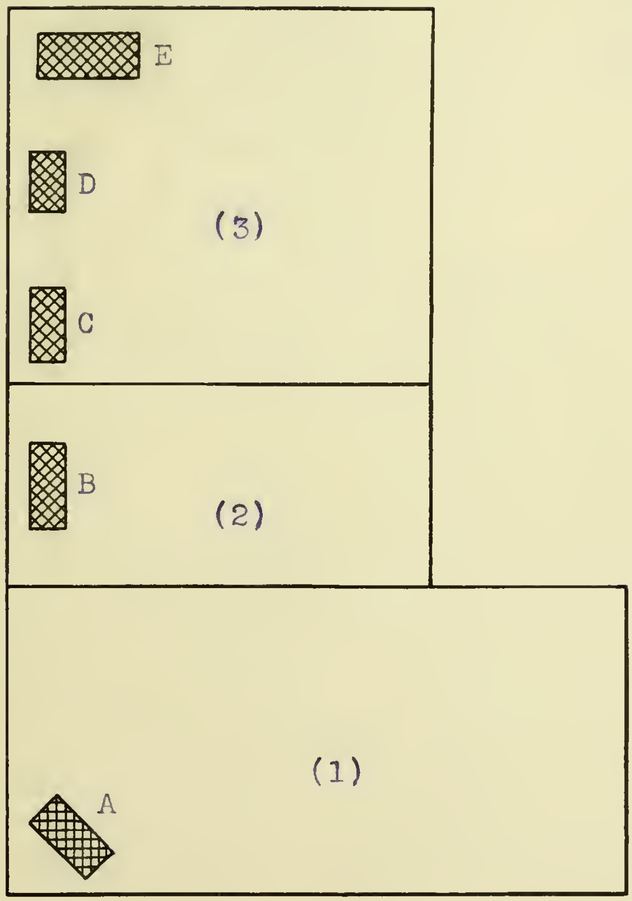
CUBICAL CONTENTS OF ROOM					EXTERNAL SURFACE		
No.	Length	Breadth	Hgt.	Volume Cu. Ft.	Length	Height	Area Sq. Ft.
1	18	15	13.5	3642	30	13.5	405
2	19	14	13.5	3600	14	13.5	189
3	41.2	18.9	13.5	10500	60	13.5	811
				17742			1405
						Glass	322
					External	Wall	1083

No. of Room	GLASS SURFACE			RADIATING SURFACE							
				EXPOSED PIPE			RADIATORS				
	Height	Width	Area	Diam.	Length	Area	No.	No. of Coils	Hgt.	Area	Make
	2.25	17.2	38.7				A	27	32	108	Holland
	9.9	8.6	85.0				B	10	44	60	2-col'm
	6.6	8.6	56.7				C	14	"	84	"
	16.5	8.6	142.0				D	12	"	72	"
			322.				E	15	"	90	"
										414	

For example, say radiators A and B were turned on, then referring to the sheet, the sum of the square feet of surface in A and B is the radiation in use in this particular room.

Before taking any tests, the buildings on the system were measured in order to determine the cubical contents, external wall surface, glass area, and radiating surface as the data on the preceding sheet indicates.

HERALD OFFICE PLAN.



Showing the location of radiators for reference in the table.

TEST NO. 1.

URBANA HEATING PLANT---------FEBRUARY 14, 1903.

No.	Time	Return System Meter Reading in Cu. Feet	Water Temp. °F	Boiler Pressure	Press. in Main	City Water Meter Reading	Temp. of Room	Outer Temp. °F.
	A. M.			#	#			
1	11:14	99397	177	95	1-1/3	863014	70	38
	P. M.							
2	1:29	99480	175	108	2	863096	"	39
3	3:11	99540	176	104	2-1/2	863166	"	36

CALIBRATION OF

NEPTUNE WATER METER NO. 68874.

METER READINGS				WATER IN TANK			ERROR IN PER CENT
No.	1st.	2nd.	Diff. in Cu.ft.	Wt.	Temp °F	Cu.ft.	High
1	925087	925094	7	418	56	6.7	.044
2	925110	925117	7	408	56	6.55	.068
3	925128	925136	8	457	56	7.3	.095
4	929267	929273	6	351	58	5.63	.065
5	929675	929281	6	346	56	5.55	.081
6	929284	929290	6	351	56	5.63	.065
7	929293	929299	6	338	56	5.43	.105
8	929302	929308	6	343	56	5.5	.091
9	929311	929317	6	338	56	5.43	.105
10	929383	929389	6	338	56	5.43	.105
11	929395	929401	6	345	55	5.54	.083
12	929430	929436	6	350	55	5.56	.079

Total-----------.986

Average----.082 High.

CALIBRATION OF

SCHAEFFER AND BUDENBURG METER NO. 533.

No.	METER READINGS 1st.	2nd.	Diff. in Cu.ft.	WATER IN TANK Wt.	Temp.	Cu.ft.	ERROR IN PER CENT Low
1	99811	99817	6	380	178	6.27	.043
2	99818	99824	6	387	177	6.39	.061
3	99826	99832	6	371	188	6.15	.020
4	99834	99840	6	381	186	6.30	.047
5	99842	99848	6	377	182	6.23	.037
6	99849	99855	6	403	156	6.18	.029
7	99857	99863	6	383	172	6.30	.047
8	99868	99874	6	397	148	6.48	.074
					Total		.358

Average .045 Low.

TEST NO. 1.

ON WHOLE PLANT FEBRUARY 14, 1907.

1 Duration of test ------------------------------3hrs. 57min.

2 Amount of water condensed in returning system ---- 9011 #

3 " " " " " non-returning " ---- 8798 #

4 Average " " " ret. sys. hourly ---- 2280 #

5 " " " " non-ret. " " ---- 2223 #

6 Radiation in use on returning system ------------ 10351 sq. ft.

7 " " " " non-ret. " ------------- 4605 " "

8 Water condensed per sq.ft. of radiation
per hour on returning system ----- .226 #

9 Water condensed per sq.ft. of radiation
per hour on non-ret. system ------ .480 #

10 Water condensed per gross cu.ft. of space per hr.-.0036 #

11 Temperature of returned water --------------------- 176 °F.

12 Average external temperature ------------------------38 "

13 " temperature in rooms ------------------------70 "

14 " steam pressure in main ---------------------- 2 #

15 H. P. required per hour for whole plant -----------150.1

TEST NO. 2.

ON WHOLE PLANT-------------- MARCH 24, 1907.

1 Duration of test ---------------------------- 4hrs. 45min.

2 Amount of water condensed in returning system ---- 12996 #

3 " " " " " non-ret. " ---- 10092 #

4 Average " " " returning sys. hourly- 2736 #

5 " " " " non-ret. " " 2125 #

6 Radiation in use on returning system ------------- 11065 sq. ft.

7 " " " " non-ret. " ------------- 4663 " "

8 Water condensed per sq. ft. of radiation
per hour on returning system ------ .259 #

9 Water condensed per sq. ft. of radiation
per hour on non-ret. system ------- .456 #

10 Water condensed per gross cu. ft. of space per hr.-.0039 #

11 Temperature of returned water --------------------- 188 °F.

12 Average external temperature --------------------- 34 "

13 " temperature in rooms --------------------- 70 "

14 H. P. required per hour for whole plant ----------- 162

METHODS OF CALCULATION.

Items (1), (2), (3), (6), (7), (11), (12), (13) and (14) are observed data.

Item (4) = (2) divided by (1).

" (5) = (3) " " (1).

" (8) = (4) " " (6).

" (9) = (5) " " (7).

" (10) = ((4) plus (5)) divided by 1275452.

" (15) = " " " " " 30.

Tests on the mains.

OBJECT

The object of the tests made on the mains was to find the rate of condensation in pounds of water per square foot of main area per hour.

METHODS OF PROCEDURE

The tests were made in the following manner. The customers were all shut off from the main and then the steam was turned on at about the same pressure as was normally used in the tests on the whole system. When the mains had become well heated and the condensation seemed nearly uniform, the tests were begun. The time of starting being noted, the steam pressure, the temperature and weight of condensation water were observed. The condensation was measured at the plant and also at Clark's Marble Works; that from the returning system at the former and that from the non-returning at the latter. The tests were stopped in a manner similar to that above described for starting. Steam was allowed to circulate through the mains about twenty hours before the tests were made.

TEST NO. 1.

ON THE MAINS---------------------MAY 14, 1903.

1 Duration of test ---------------------------------- 3hours

2 Total water condensed in return main ------------- 512 #

3 " " " " non-returning main ------ 213 #

4 Average water condensed hourly in return main ---- 171 #

5 " " " " " non-ret. " ---- 71 #

6 External pipe area in return main --------------- 2177 sq. ft.

7 " " " " non-ret. " --------------- 987 " "

8 Water condensed per sq.ft. of return main per hr.-.078 #

9 " " " " " " non-ret. " " " -.073 #

10 Temperature of water from return main ------------ 195 °F.

11 " " " " non-ret. " ------------ 129 "

12 Average external temperature -------------------- 62 "

13 " steam pressure in main ----------------2-3/4 #

14 H. P. required per hour -------------------------- 8

METHODS OF CALCULATION.

Items (1), (2), (3), (6), (7), (10), (11), (12) and (13) are observed data.

Item (4) = (2) divided by (1).

" (5) = (3) " " (1).

" (8) = (4) " " (6).

" (9) = (5) " " (7).

" (14) = ((4) plus (5)) divided by 30.

Auxiliary Tests on Water Rate of Installation at Columbian Hotel.

DESCRIPTION OF APPARATUS.

The apparatus used in connection with these tests consists of an American District Steam Co's. water meter #555 connected to the discharge pipe from the cooling coil to measure the water of condensation from the building. A steam gauge was attached to the steam trap to ascertain the pressure in the main. Thermometers were used to determine the temperature of condensation water, external air, and air in the building.

Photograph of meter, steam trap, and cooling coil in basement.

METHODS OF PROCEDURE.

The tests on the hotel were conducted as follows:- The meter was read, the time noted, the steam pressure taken and the temperature of the water of condensation, external air and internal air observed. Then all the radiators were visited and the ones that were in operation noted in order that the square feet of radiation heating the building at that time could be calculated. All the readings wre repeated several times during the day and each test was stopped by taking readings similar to those in starting.

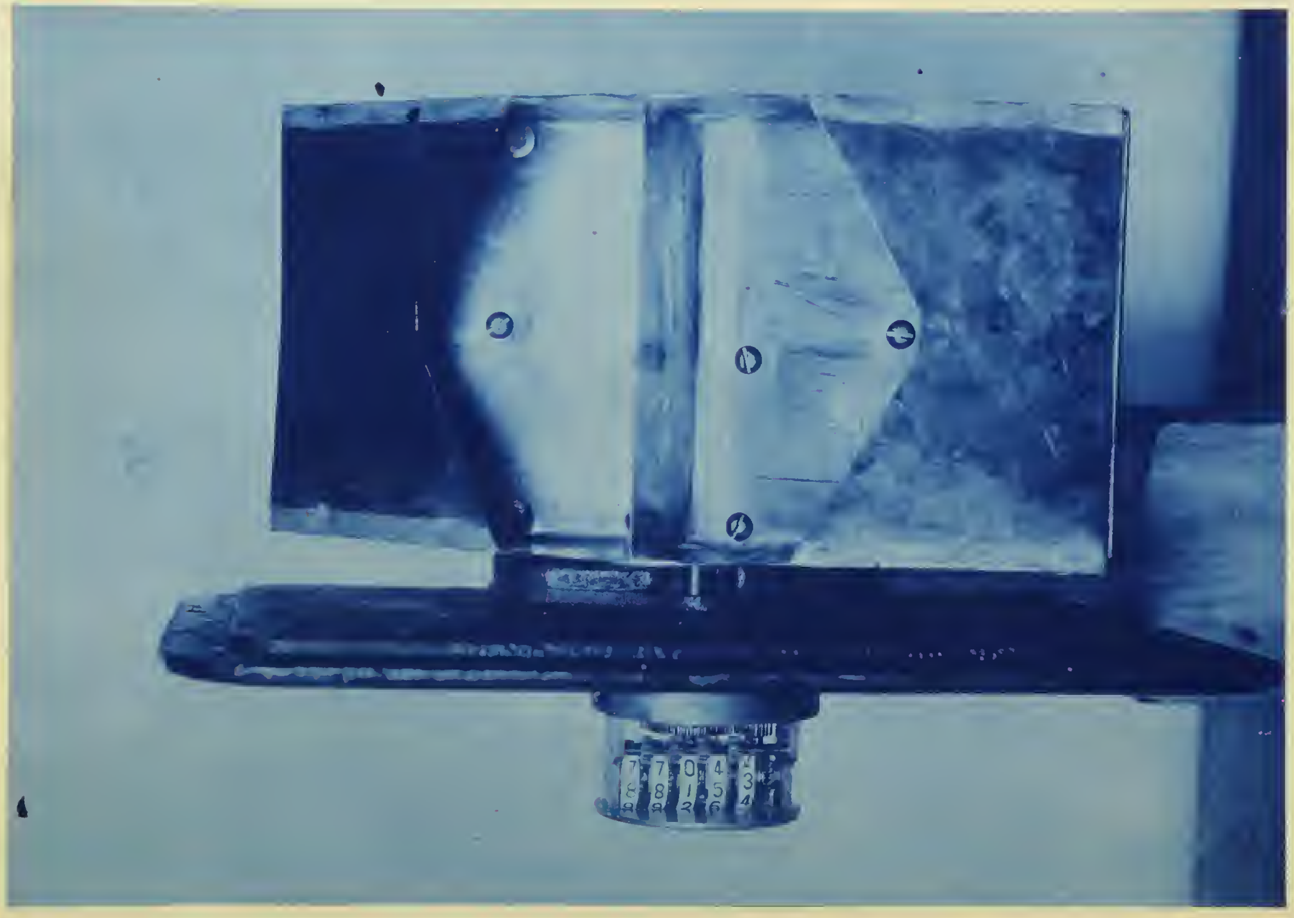
CALIBRATION OF METER.

Meter #555, manufactured by the American District Steam Co. of Lockport, New York, was calibrated as follows:-
The water of condensation after passing through the meter was conveyed through a pipe to a tank balanced on a pair of scales. The rate of flow was regulated by opening or closing the radiator valves in various parts of the building. In starting a calibration test, the scales were balanced while the water was running through the valve in the bottom of the tank, and at a given signal the meter was read, the tank valve closed, and the time noted. The temperature of the water of condensation was observed frequently. To stop the test simultaneous readings were taken of the meter, time, and the weight on the scales; the latter being continually balanced throughout the test.

FRONT VIEW OF AMERICAN DISTRICT STEAM CO'S. WATER METER.

BACK VIEW OF INTERIOR OF METER.

TOP VIEW OF INTERIOR OF METER.



CALIBRATION OF

AMERICAN DISTRICT STEAM CO'S. METER NO. 555.

No.	METER READINGS 1st.	2nd.	Diff. in pounds	WATER IN TANK Wt.	Temp. °F	RATE OF FLOW #per hr.	ERROR IN PER CENT High
1	394986	395286	250	246	118	231	.016
2	395350	395550	200	195	120	224	.025
3	399560	399810	250	247	116	224	.012
4	399830	400080	250	245	118	267	.021
5	400100	400350	250	246	120	254	.016
						Total	.090

Average------.018 High.

TABLE SHOWING CUBICAL CONTENTS, OUTSIDE WALL,

GLASS AREA, AND RADIATION OF COLUMBIAN HOTEL.

Name		Cu. Ft. of Air Space	Sq. Ft. of Outside Wall	Sq. Ft. of Glass	SQ. FT. OF RADIATION From Radiators	From Exposed Pipe	Total
		1	2	3	4	5	6
Lowenstern's	1	42045	597	244	307	10.9	317.9
Columbian Hotel	1	27906	961	221	541	24.5	565.5
" "	2	66531	2669	488	524	20.1	544.1
" "	3	26094	1140	320	183		183.0
(Same) Basement		6500	188	64		80.0	80.0
Totals----		169076	5555	1307	1555	135.5	1690.5

Name	Floor	SAME BY MILL'S RULE OF THUMB Space Cu. Ft. 200	Ex. Wall Sq. Ft. 20	Glass Sq. Ft. 2	Total	Ratio of Radiation to space
		7	8	9	10	11
Lowenstern's	1	210	29	122	361	132
Columbian Hotel	1	139	48	111	298	49
" "	2	333	134	244	711	122
" "	3	130	57	160	347	142
" " Basement		32	9	32	73	81
Totals----		844	277	669	1790	

TEST NO. 1.

COLUMBIAN HOTEL--------------FEBRUARY 13, 1903.

No.	Time	Meter Reading	Temperatures (Degrees F.) Outside	Inside	Conds. Water	Pressure in the Main #	Weather
	A. M.						
1	8:58	30570	34	69	121	1-1/2	Cloudy
2	10:37	31150	35	69	123	1-3/4	"
3	11:24	31420	35	70	124	"	"
4	11:58	31620	36	70	120	"	"
	P. M.						
5	1:32	32180	36	70	122	2	"
6	2:35	32540	36	70	121	1-1/2	"
7	3:31	32880	34	70	123	2-1/2	"
8	4:35	33160	33	68	121	1-1/4	"
9	5:00	33280	33	66	122	1-1/2	"

TEST NO. 1.

COLUMBIAN HOTEL---------FEBRUARY 13, 1903.

1	Duration of test----------------------------------	8hrs. 2min.
2	Meter reading 8:58 A. M. ----------------------	30570 lb.
3	" " 5:00 P. M. ----------------------	33280 "
4	Total water condensed (corrected) ----------------	2666 "
5	Average " " hourly --------------------	332 "
6	Amount of radiation in use ----------------------	925 sq.ft.
7	Water condensed per sq.ft. of radiation per hour--	.36 lb.
8	" " " gross cu.ft. of space " " --	.00196 "
9	Temperature of condensed water--------------------	122°F.
10	Average external temperature --------------------	35 "
11	" temperature in building ------------------	69 "
12	" steam pressure in main ------------------	1.7 #
13	H. P. required per hour --------------------------	11.06

Weather cloudy all day.

TEST NO. 2.

COLUMBIAN HOTEL-----FEBRUARY 14, 1903.

1	Duration of test	4hrs. 40min.
2	Meter reading 12:15 P. M.	39450 lb.
3	" " 4:55 " "	40920 "
4	Total water condensed (corrected)	1450 "
5	Average " " hourly	312 "
6	Amount of radiation in use	1059 sq.ft.
7	Water condensed per sq.ft. of radiation per hour	.295 lb.
8	" " " gross cu.ft. of space " "	.00185 "
9	Temperature of condensed water	124 °F.
10	Average external temperature	36 "
11	" temperature in building	70 "
12	" steam pressure in main	3/4 #
13	H. P. required per hour	10.4

TEST NO. 3.

COLUMBIAN HOTEL------MARCH 20, 1903.

1	Duration of test ------------------------------	7hrs. 55min.
2	Meter reading 8:35 A. M. --------------------	278840 lb.
3	" " 4:30 P. M. --------------------	281040 "
4	Total water condensed (corrected) --------------	2160 "
5	Average " " hourly ------------------	277 "
6	Amount of radiation in use --------------------	1189 sq.ft.
7	Water condensed per sq.ft. of radiation per hour --	.233 lb.
8	" " " gross cu.ft. of space " "	.00164 "
9	Temperature of condensed water -----------------	123°F.
10	Average external temperature --------------------	35 "
11	" temperature in building -----------------	70 "
12	" pressure in steam main -----------------	1/2 #
13	H. P. required per hour -----------------------	9.2

Weather cloudy all day.

TEST NO. 4.

COLUMBIAN HOTEL------MARCH 24, 1903.

1	Duration of test	4hrs. 57min.	
2	Meter reading 10:35 A. M.	304830	lb.
3	" " 3:32 P. M.	306550	"
4	Total water condensed (corrected)	1690	"
5	Average " " hourly	341	"
6	Amount of radiation in use	1172	sq.ft.
7	Water condensed per sq.ft. of radiation per hour	.29	lb.
8	" " " gross cu.ft. of space " "	.002	"
9	Temperature of condensed water	126	$^{\circ}$F.
10	Average external temperature	30	"
11	" temperature in building	69	"
12	" pressure in steam main	2-1/2	#
13	H. P. required per hour	12.1	

Cloudy.

TEST NO. 5.

COLUMBIAN HOTEL -------- APRIL 3, 1903.

1	Duration of test	1hr. 37min.
2	Meter reading 10:12 A. M.	360370 lb.
3	" " 11:49 " "	360860 "
4	Total water condensed (corrected)	482 "
5	Average " " hourly	298 "
6	Amount of radiation in use	971 sq.ft.
7	Water condensed per sq.ft. of radiation per hour	.306 lb.
8	" " " gross cu.ft. of space " "	.00176 "
9	Temperature of condensed water	123°F.
10	Average external temperature	29 "
11	" temperature in building	69 "
12	" steam pressure in main	2-1/2 #
13	H.P. required per hour	9.93

Rainy weather.

TEST NO. 6.

COLUMBIAN HOTEL ------- APRIL 22, 1903.

1	Duration of test ------------------------------	5hrs. 43min.
2	Meter reading 9:26 A. M. --------------------	450524 lb.
3	" " 3:09 P. M. --------------------	452050 "
4	Total water condensed (corrected) -------------	1498 "
5	Average " " hourly ------------------	262 "
6	Amount of radiation in use --------------------	908 sq.ft.
7	Water condensed per sq.ft. of radiation per hour	.289 lb.
8	" " " gross cu.ft. of space " "	.00152 "
9	Temperature of condensed water -----------------	121°F.
10	Average external temperature -------------------	43 "
11	" temperature in building ----------------	69 "
12	" steam pressure in main -----------------	1 #
13	H. P. required per hour -----------------------	8.75

METHODS OF CALCULATION.

Items (1), (2), (3), (6), (9), (10), (11) and (12) are observed data.

Item (4) = (3)minus(2)multiplied by 98.2 %.

" (5) = (4)divided by(1).

" (7) = (5) " " (6).

" (8) = (5) " " 169076.

" (13) = (5) " " 30.

GENERAL RESULTS FROM ALL TESTS.

The tests on the Columbian Hotel were made mainly to determine the water-rate of the building per square foot of radiation. By so doing it was possible to check the results of the water-rate of the whole system, since this building represented the average conditions of the system. The water-rate of the returning system compared very closely with that at the hotel; but owing to the leaks in the system, to the impossibility of measuring the condensation from the engines and pump, or to the inaccuracy of observations, the non-returning system gave results somewhat high. The test on the main, although made in warm weather, indicates that a very small per cent of the heat is dissipated in the main itself.

In moderately cold weather when considering the whole system it was found that approximately one- third of a pound of water is condensed from one square foot of radiation in one hour.

CONCLUSION.

After reviewing this central heating system and making the few foregoing tests, the authors have arrived at the following conclusions.

Generally speaking, the installation is of the modern type. Situated as it is in the business center of the City of Urbana, and since the exhaust steam which is a by-product of the electric lighting and power plant is used for heating during the greater part of the year, it seems to be a good business proposition. From the fact that no complaints were heard from the consumers, the plant seems to be on the whole satisfactory and useful to the community.

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